THE EXPLOSIVE COMPONENT WATER GAP TEST

Lt Col A J Morley
Ordnance Board, United Kingdom

ABSTRACT

In the safety assessment of munitions, the explosives used must be identified. In addition to national legislation and regulatory requirements, the safety and suitability of the explosives for use by military services is assessed according to STANAG 4170 before selection and incorporation into the munition.

Explosive components used in fuzing systems normally contain explosives which are more sensitive than main charge explosives. Small changes of loading conditions involving e.g. pressure-density and/or confinement can radically alter their performance and characteristics, which can affect their safety. Therefore it is essential that these effects are thoroughly assessed during development and, if necessary, in production.

The Explosive Component Water Gap Test (ECWGT) has been developed to assist in this assessment. It is described and the associated documents listed. It is intended to extend the test method to cover cord- and tube-shaped explosive components as well as ignition transfer elements.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **AUG 1992**	2. REPORT TYPE	3. DATES COVERED **00-00-1992 to 00-00-1992**
4. TITLE AND SUBTITLE **The Explosive Component Water Gap Test**		5a. CONTRACT NUMBER
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **UK Ordnance Board, ,Bristol, United Kingdom,**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADA260986, Volume III. Minutes of the Twenty-Fifth Explosives Safety Seminar Held in Anaheim, CA on 18-20 August 1992.

14. ABSTRACT
see report

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**7**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

AIM

1. The aim of this paper is give the background to, and explain the conduct of the explosive component water gap test, a means of testing the shock sensitiveness of explosive components cheaply and in a reproducible manner.

BACKGROUND

2. The NATO AC 310, Sub-group II is responsible for developing the philosophy for fuze safety and the test regimes for fuzes within NATO. One of the many successes of this group over the last few years is to publish the test described in this paper as a NATO standardisation agreement or STANAG. At this stage tribute must be paid to the primary author of this paper, Dr Bartels, who until he retired last year was working for BICT in Germany.

DESIGN REQUIREMENTS

3. For any of you not familiar with NATO standardisation agreements or STANAGs for short, the main one on fuzing systems is STANAG 4187 [1]. Among other requirements this STANAG demands that explosives and explosive compositions for fuzing systems shall be assessed and qualified in their design role so that the munition is safe and remains so under the specified conditions of storage and use. As a precondition the safety and suitability of the explosives for use by military service must be assessed, in addition to national legislation requirements, according to STANAG 4170 [2].

4. Explosive components used in fuzing systems normally contain explosives which are more sensitive than main charge explosives. The safety hazard created by primary explosives and comparable compositions, normally only loaded in detonators and other initiators, can be eliminated by a shutter in a fuze safety and arming device. As a result the need to endorse the related design safety requirements of STANAG 4187 should be sufficient for these very sensitive components.

5. Only those explosives qualified in accordance with the requirements of STANAG 4170 as acceptable expulsion charges and lead or booster explosives, are permitted to be in a position leading to the initiation of a high explosive main charge without an interrupter being present. They shall not be altered during their lifetime (manufacture to target sequence) by any means likely to increase their sensitiveness beyond that for which the material was qualified and at which it is customarily used.

EXPLOSIVE CHARACTERISTICS AND ASSESSMENT

. The characteristics of explosive materials are changed when ontained, pressed or associated with other materials in an xplosive component. Even small changes involving for example ressure-density and/or confinement can radically alter their erformance and characteristics, and which can ultimately affect heir safety. To assess the effects of these changes and to dentify the safety relevant data of lead and booster compositions sed for qualification as well as for pilot lot acceptance tests, evelopment testing for the characterisation and safety appraisal of hese components should be standardized. Until now the criteria sed by individual nations to qualify or accept lead and booster omponents have not be collated, readily available nor well ocumented. This often has delayed the acceptance of these omponents by other nations, hindered interoperability and wasted ime and money for re-characterisation. This lack of a standard led o the promulgation of STANAG 4363 "Fuzing Systems, Development esting for the Assessment of Lead and Booster Components" [3].

. The STANAG is the covering document for the Allied Ordnance ublication 21 (AOP-21) [4], which contains a detailed description f the different applicable test methods and procedures. The greement stated the responsibility of the developing nation for onducting testing as well as for providing copies of the relevant esign characteristics, safety analyses and the reports of trials onducted. It confirms the requirements concerning the stability nd compatibility of the incorporated explosives, regulates changes o the agreed assessment procedures detailed in AOP-21 and describes he documentation of a safety statement in combination with a data heet.

. The AOP describes the test procedures and test item onfiguration and states the information required before and after esting, required test conditions and acceptance criteria for evelopment testing of lead and booster explosive components used in uzing systems in either interrupted or non-interrupted explosive rains. To ensure the validity of the tests it is vital that the etailed specification of the component and explosive filling are ade available from the design authority concerned. The components nder test should be manufactured to approved (frozen) drawings and aken randomly. In case of specification changes affecting safety he components would have to be re-tested.

. The safety of these components within a fuzing system depends rincipally on their thermal stability and sensitiveness to shock timuli. Thermal stability testing is conducted at the system level ith the component incorporated in its respective fuzing system. he shock sensitiveness can be determined before it is selected for

a specific use. For lead or booster components not exceeding 15 mm in diameter the explosive component water gap test (ECWGT) is a suitable test.

10. The Explosive Component Water Gap Test. The test, the equipment is shown in Figure 1, involves subjecting lead or booster components to a series of selected shockwave stimuli which are generated by a standardised explosive donor and attenuated by a column of distilled or deionised water. A witness rod is used to assess whether or not the lead or booster has reacted.

11. By conducting a series of Bruceton Tests the "no go" value is determined and the measured water gap value is converted to the relative shock pressure. The test results represent the effects of the explosive loading, its confinement and pressing density. A detailed test procedure including a set of drawings for the test equipment, a data sheet format as well as examples for calculation and filling up and a table for conversion of ECWGT results (mm water gap to shock pressure) are contained in AOP-21, Annex B [4]. An example of a completed ECWGT data sheet is at Annex A.

12. A component will be considered suitably insensitive to shock to enable its use in future uninterrupted explosive trains if its "no-go" level is less than or equal to 28 mm of water corresponding to a shock pressure level of 10.7 kbar. This level derives from a pellet of "NATO-tetryl" compacted to a density of 1.55 g/cc and qualified in accordance to STANAG 4170 [2].

13. The shock sensitiveness of components with diameters greater than 15 mm may be assessed by conducting a gap test on the explosive material provided that it has been manufactured to the same pressing density. The gap test is used to assess the effects of a particular environment on a component by conducting the gap test on a sample of the components before submitting similar components to the environment and then a gap test. This will show whether the shock sensitivity has been adversely affected. Such an environment could be the thermal shock test.

14. Characterisation Test. This test should be conducted to confirm the applicability of the lead or booster component for its intended role within a fuzing system. The ECWGT represents a suitable test procedure. For characterisation, a modified Bruceton Test [5] provides the mean value of shock sensitiveness and its standard deviation. The test therefore provides evidence towards determining the applicability of that component to fulfil a particular requirement in the explosive train.

15. Reporting Data Sheet. Nations which develop lead and booster explosive components shall provide the detailed results of any safety and characterisation tests that have been conducted. These results shall be available to other National Safety Approving Authorities as a part of the safety statement. When requested by NATO countries procuring these components, nations shall provide a data sheet defining the specific component including:

> Nomenclature and dimensions, identification including drawing and specification numbers, a drawing, general background data, Qualification/Assessment status, material data, safety and characterisation results, additional remarks including Compatibility Statement.

SUMMARY AND FORECAST

16. The explosive component water gap test is simple and cheap to conduct, it lends itself to statistical analyses. I believe it is a valuable test and would also be a very useful one for manufacturers as a quality control test during batch production of such components. It can also assist in determining the causes of system failures using data based on previous component tests.

17. Test development is not standing still. Its use to test cord and tube shaped explosive components as well as igniting cord components is being investigated. Tests are currently being performed in Françe, Germany and the UK on pyrotechnic cords. Once these test haves been completed successfully then the modified test procedure will be included in AOP 21 [4].

References:

[1] STANAG 4187 Fuzing Systems - Safety Design Requirements

[2] STANAG 4170 Principles and Methodology for the Qualification of Explosive Materials for Military Use

[3] STANAG 4363 Fuzing Systems - Development Testing for the Assessment of Lead and Booster Components

[4] AOP-21 Fuzing Systems - Manual of Development Characterisation and Safety Test Methods and Procedures for Lead and Booster Explosive Components

[5] W J Dixon & F Massey Jr An Introduction to Statistical Analysis New York, McGraw-Hill,(1951), pg 279-287

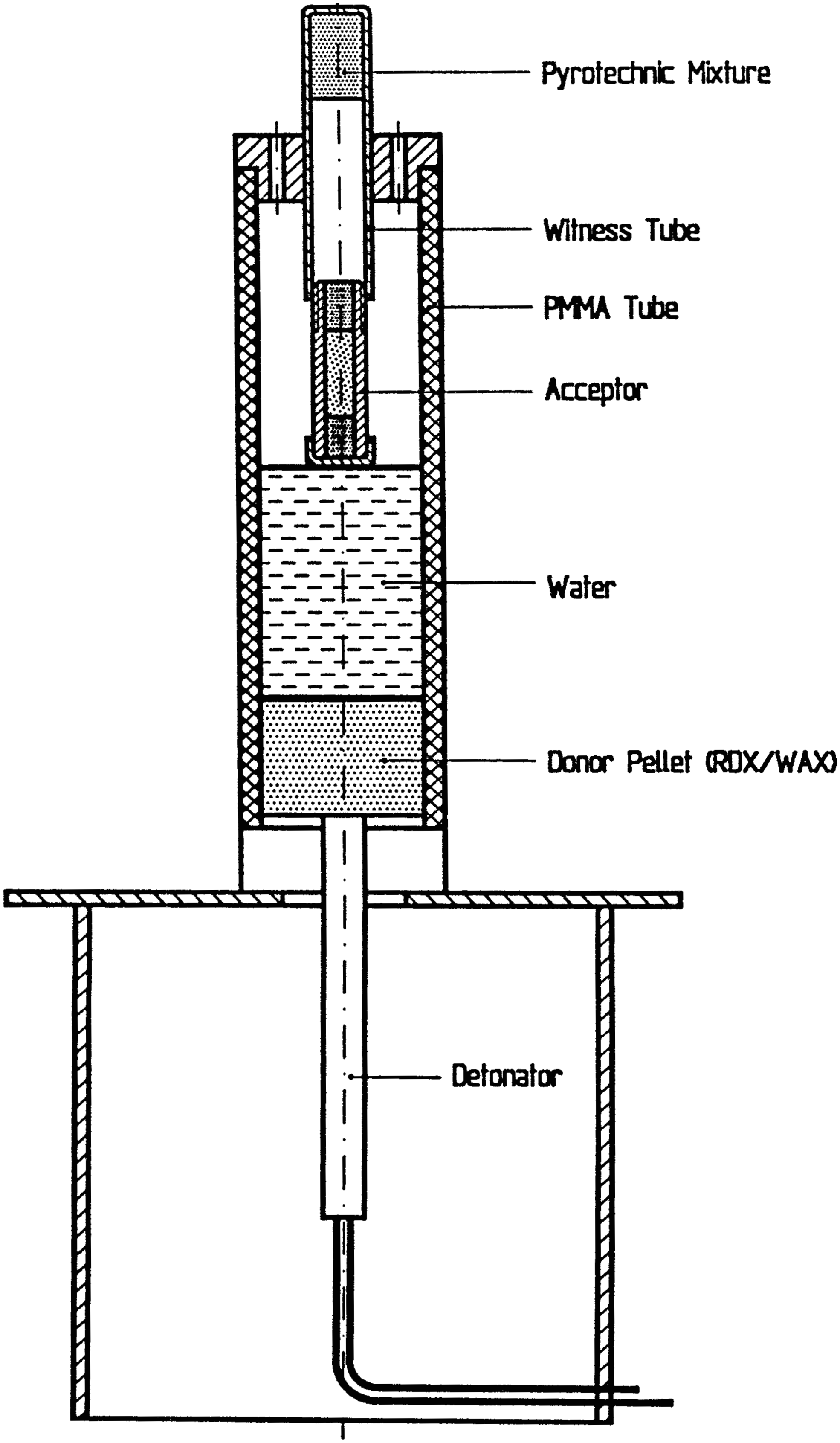


Fig. 1 Ignition Component
Water Gap Test

Explosive Component Water Gap Test (ECWGT)

Explosive Component (EC) : Booster XYZ **EC Data sheet No. :**

Lot No. : 123 **Manufacturer :** An explosives company

Explosive Filling : SS C 8042 (Tetryl) **Filling Weight :** 3.15 g **Loading Density :** 1.58 gcm^{-3}

Acceptor Orientation : Bottom of case in contact with water gap

Legend : – = no Reaction, x = Explosion

	Characterization - Test																				Safety - Test				
Water Gap \ Trial No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
H_0 = 22 mm															x				x						
H_1 = 23 mm		x				x		x		x		x		–		x		–		–					
H_2 = 24 mm	–		x		–		–		–		–		–				–								
H_3 = 25 mm				–																	–	–	–	–	
H_4 = mm																									
H_5 = mm																									

H_0 = minimum water gap

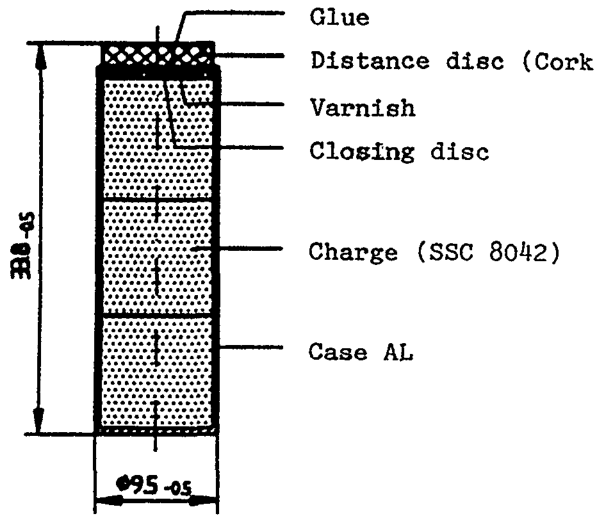
Calculation

H (mm)	i	n +	n -	$i \cdot n^{\pm}$	$i^2 \cdot n^{\pm}$
22	0	2	0	0	0
23	1	6	3	6	6
24	2	1	7	2	4
25	3	0	1	–	–
	4				
	5				
Σ		$N^+ = 9$	$N^- = 11$	A = 8	B = 10

$\Sigma n^+ \leqslant \Sigma n^-$, use n^+

$\Sigma n^+ > \Sigma n^-$, use n^-

Drawing :



Median $M_{50} = H_0 + \frac{A}{N} \pm 0.5$ ** $22 + \frac{8}{9} + 0.5$

Standard Deviation $S = 0.05 + 1.6 \frac{(N \cdot B - A^2)}{N^2}$

** if using N^+ add 0.5
 if using N^- subtract 0.5 $S = 0.05 + 1.6 \frac{90-64}{81}$

Median : 23.4 mm Water Gap, equivalent to a pressure of approximately 15 kbar

Standard Deviation : 0.56 mm Water Gap